--ACTIVITY 5
Teachers Section

ANATOMY OF AN IMPACT

MATERIALS

Each group will need

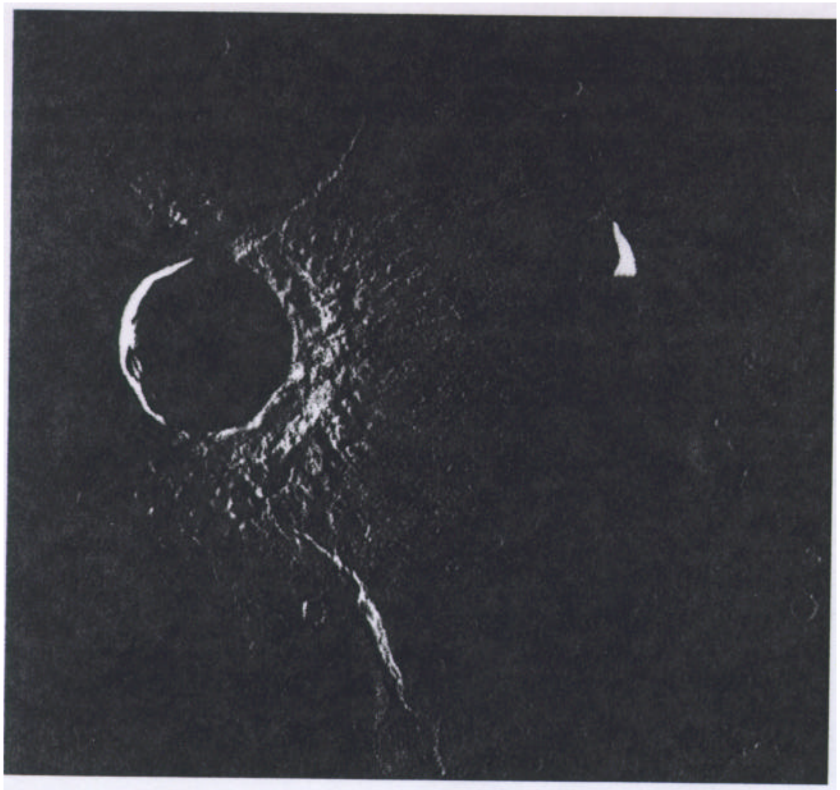
- copies of crater photographs
  (two for each group)
- drawing paper
- pencils You also will need to prepare
model craters like the ones created in Activity 3.

WHAT IS HAPPENING?

Scientific research involves models. Forexample, scales represent objects in manageable sizes, and dynamic models simulate processes. Students need to appreciate how models are used in scientific research. They also must learn how to evaluate models for strengths and weaknesses. The best way to gain this appreciation for the role and limitations of models is to compare results directly from real and model circumstances. In this activity, students examine photographs of real impact sites for comparison withthose produced in a model.
With the memory of the model fresh (and additional ones on hand for study), comparison is effective and illustrative of both the benefits and limitations of modeling.

Although the model developed for Activities 3 and 4 is good in many respects, its main limitationinvolves the speed of impact for the falling body. Real lunar and planetary impacts occur at
speeds much greater than the speed of sound. These speeds are called hypersonic.
When bolides fall this fast, a pressure wave (traveling at the speed of sound) builds up in the rock. Just before the bolide would actually strike the surface, something peculiar happens. The pressurewave that builds up cannot carry energy away from the impact fast enough to "get out in front"of the bolide. As a result, the energy and heat created by the impact concentrate, and an explosion occurs! Thus, the effects of a hypersonic impact are really caused by an explosion and not by a collision. The explosion is frequency underground, after the bolide has punched a hole in the surface.
In the model, impact speeds are much slower than the speed of sound. In fact, simulated bolides must be thrown relatively hard to create enough air pressure in front to throw out the powder representing the surface layer. This creates something of a "simulated" explosion, although the bolide itself is not destroyed.

Analyzing lunar photographs from orbital height, planetary scientists can compare features of real impact craters to features



Spectacular image of crater and ejecta blanket. All the radiating material was ejected from the crater and dumped on the surface.. On Craters!-CD this is image Moon310.tif.

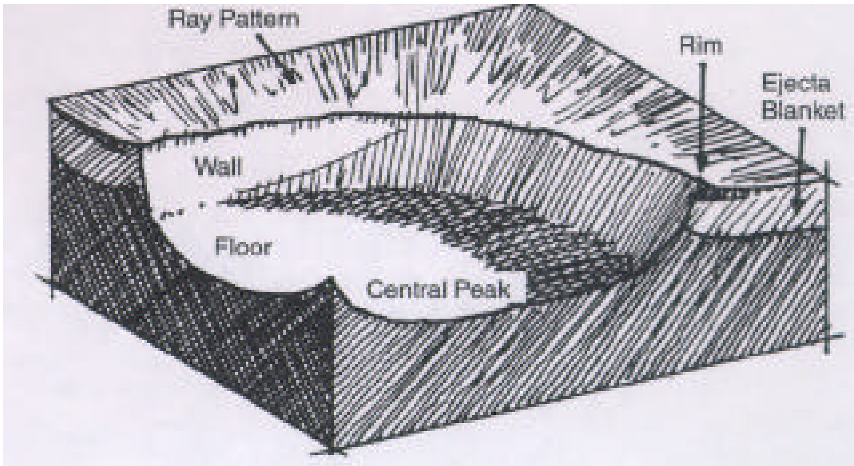
produced in models. Students should be able to identify a number of key features in their photographs. These features include

- **Crater's raised rim**

- **Crater's central peak (if present)**

- **Ejecta blanket of debris, thrown out by the explosion and deposited outside the rim in a ray pattern outward in decreasing volume**

- **Overturned strata or rock layers**



Schematic of crater and key features. Note that only larger lunar craters, bigger than 10 km in diameter, have central peaks. This is because central peaks are caused by a rebound-like phenomenon that occurs only at larger scales.

When examining their photographs, students might benefit from the following information:

Crater shape: Small craters typically have a smooth, bowl-shaped interior. In large impacts, the energy involved and the weight of the crater walls are so large that a rebound phenomenon occurs. After being pushed down by the initial explosion, the bottom center of large craters rebound upward again, assisted by the weight of the newly-created walls. This rebound produces a central peak. Students usually do not identify this peak as being part of the crater. They can confirm that the peak appears in large but not small craters for themselves, although later events, such as lava flows filling a crater, can obscure some peaks. (Students can simulate the appearance of this central peak using water droplets.) During impact, steep crater walls are created. These walls are then subject to landslides and slumping. A landslide will have an irregularsurface; slump blocks will look like a series of terraces or steps on the inner wall of the crater.

Identifying the ejecta blanket: The material blown out from the crater during an impact flies outward and piles up on the outer rim and beyond. This scattering is largely responsible for the crater's raised rim. (The raised rim also results when the impact explosion bends the surrounding strata upward.) More debris falls closer to the rim than farther away. The debris field forms what is called an ejecta blanket, and this blanket usually forms a feather or ray pattern, thinning with distance. The ejected rays of fine, bright, pulverized material are one of the ejecta blanket features best simulated in Activity 3.

Composition of the ejecta blanket: Impacts disturb local geology. If a bolide falls on an undisturbed surface, the rock found under the ejecta blanket will be original—i.e., undisturbed—rock from the area. The ejecta blanket itself would consist of material blownout of the site of the explosion. Because the temperatures and pressures

Additional impacts on the Moon. On Craters!-CD this is image Moon303. tif.

produced during the explosion are so high, material in the ejecta blanket can include rock that was highly fractured, heated, or melted. These shocks produce distinct effects in rock, and geologists studying samples from ejecta blankets usually have little difficulty identifying them as such.

Stratigraphy: Because the ejecta blanket forms at the same time as the crater, it creates a widespread layer equal in age to that crater. Later craters lay down other ejecta blankets atop the first. These layers can be distinguished in photos from space or on the ground. Geologists study this layering and compare it to rock layers elsewhere to unravel the geological history of a region. This practice is called stratigraphy. Stratigraphy is presented further in Activity 14.

IMPORTANT POINTS FOR STUDENTS TO UNDERSTAND

• A surprising amount of information can be extracted by studying photographs only.

• Models are useful tools for research and verification.

• Models always are imperfect representations. Knowing their limitations is as important as knowing their advantages.

• Real and model craters have important differences. Studying cratering simply from models has its limitations.

PREPARATION

Students begin this activity working alone, then complete the activity in groups of three or four. Work with images of the Moon for this activity. Several are printed here for your use. Many others are available on Craters!-CD and elsewhere (see Resources List). You might consider assigning different images to different student groups.

In advance, prepare crater models for each group, or one for the class that groups can take turns examining, following the method provided in Activity 3 and 4. Leave the models exactly as they are following the impact. For your convenience, Appendix I provides more background information about the cratering process.

SUGGESTIONS FOR FURTHER STUDY

Models are common in scientific research. Students can investigate the use of models both inside and outside planetary sciences. Models of molecules have enabled chemists to visualize chemical reactions better. Topographic maps are models of landscapes. In recent years, computer modeling and simulations have become widespread (e.g., in meteorology), and students can explore these applications. Models do not necessarily need to look like what they represent. But they must act like what they represent.

Students also can investigate how different technologies produce high resolution photographs of planetary bodies. Compare ground and space-based telescopes with planetary probes. Photographsalso are produced during human exploration in space. Students can investigate the results of those projects. Especially interesting are the Apollo missions to the Moon.

CONNECTIONS

Models are common outside the sciences too. Ask students to compare the use of models in science to the use of metaphors and analogies in literature, film, and music.

ANSWERS TO QUESTIONS FOR STUDENTS

1. Answers will vary.

2. Answers will vary. General problems with the model's realism will be related to scale.

3. Answers will vary with the model created. The main differences are those of scale: speed of impact, size of bolide, structure of planetary surface. Possible ways to build a more realistic model:
(I) use a higher velocity impact, made with adult supervision, or
(2) construct a deeper, multilayer surface that can be excavated in cross-section to look at subsurface impact results. Mixing grated Rim paraffin with the layers, then baking the "impact" before of excavation is one method. Adult supervision is needed.

Schematic of impact with crater formation. Use this for Question 1 in the Student Section.